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EXPERIMENTAL MELTING AND FIBERIZING OF MIXTURES OF TRAP ROCK AND CALCINED LIMESTONE FROM CRIQ

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by

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SUMMARY

Trap rock, and two mixtures of trap rock and calcined limestone, were successfully electromelted and fiberized. Wool samples at different fiberizing temperatures were collected. The addition of calcined limestone increased the electrical conductivity of the melt and greatly improved the melting operation. The inherent reducing condition in CANMET's electric furnace caused the iron oxides in the melt to be reduced. This reduction changed the viscosity of the melt and consequently made the control of the fiberization process more complex.

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INTRODUCTION

CRIQ (Centre de Recherche Industrielle du Québec) requested that CANMET investigate electromelting and fiberizing of a trap rock sample and mixtures of trap rock and calcined limestone in the Wooding electrical furnace. This work was carried out on a full cost recovery arrangement. The trap rock and limestone samples were supplied by CRIQ. CRIQ also provided chemical analyses and viscosity data. Dr. Bernard Malric of CRIQ, who was present during the four test runs, was consulted re the charge composition and the fiberization temperatures before each test.

EXPERIMENTAL WORK

SAMPLE

The chemical compositions of the trap rock and limestone are shown in Table 1. The trap rock was crushed to minus 0.6 cm and the limestone ground and calcined in CRIQ's laboratory before delivery to CANMET.

Table 1 - Chemical compositions of samples

Sample	CaO	SiO_2	Al_2O_3	MgO	Fe_2O_3	LOI
Trap rock	11	33	23.6	5.8	15	--
Limestone	40.8	12.9	4.7	1.1	1.7	34

PROCEDURE

A layer of 5-8 cm of blended charge material (2270 g) was placed in the bottom of the crucible and covered by a thin layer of minus 6 mm coke. The coke, used to initiate the electrical arc, covered an area large enough to engage all three electrodes. The crucible was raised until the arc was established. As the arc initially heated and then melted the solid materials, the volume of the charge decreased. The arc was maintained by raising the crucible. When a molten pool of material was formed, the electrodes were immersed in the melt which became an ionic conductor and the furnace then functioned as a resistance-heating furnace. The depth of the molten bath was increased by feeding the balance of the charge through the feeder port continuously at a rather slow rate.

The melting current or power can be controlled manually by moving the crucible vertically. This action changes the degree of electrode immersion and consequently, the electrical resistance between the electrodes. Feeding of a 9 kg charge usually took 20-25 min.

The power consumption indicated by the kWH meter was used to determine when the approximate desired temperature had been reached. At this point, the power was shut off and the crucible quickly lowered. An immersion-thermocouple-lance was used to measure the glass-melt temperature, which was indicated on an associated recorder. The crucible was then raised and the required temperature reached by either continuing the supply electrical power to the furnace or by allowing the furnace to cool. The glass-melt temperature was closely monitored using the lance during this critical period.

As soon as the proper temperature was reached, the graphite plug was "punched" through the tap hole in the bottom of the furnace. As the melt flowed through the hole the melt temperature was monitored by an optical pyrometer. The melt stream was subjected to an air blast at a pressure of 620 kPa at right angles to the stream. The fiberization took place as the liquid globules formed by the impact were drawn out by air resistance during their flight. The wool was sampled at different fiberization temperatures by a net. The bulk of the wool was collected in the wool collecting chamber.

TEST RESULTS

TEST 1

Nine kilograms of trap rock were used as the charge material. Wool samples were taken at 1475 and 1420°C. Both samples were a dark green colour. The wool obtained at 1420°C was definitely too coarse indicating too low a melting temperature. A metal phase of 250 g was produced. Reducing conditions prevail in the CANMET's electrical furnace because the crucible and the electrodes are made of graphite. In addition, the electrodes are submerged in the melt. Iron oxides in the charge material are reduced and separated from the glass melt as a metal phase. The reduction of iron oxides should increase the viscosity of the melt. This was confirmed by the fact that the wool produced is coarser than predicted from the viscosity data. The viscosity was measured in an inert argon atmosphere which resulted in no reduction of the iron oxides.

TEST 2

The charge for this test consisted of 6350 g of trap rock and 2720 g of calcined limestone. The melt was tapped at 1650°C and, when air blown, produced only fine mist-like particles and no wool. Apparently, the fiberization temperature was too high and the viscosity of the melt too low. At 1575°C, very short and very fine fibres were produced. Practically all the remaining melt ran out of the furnace at 1500°C at which temperature a soft, fine, white wool was collected. About 500 g of metal was obtained which was more than twice the amount produced in Test 1, even though the charge material for this test contained less iron oxides than that for Test 1. The reason for this is that the addition of CaO (calcined limestone) to the charge material increased the activities of the iron oxides which rendered them more reducible. The white colour of the wool also indicates that most of the iron oxides had already been removed from the system. The addition of 30% calcined limestone increased the electrical conductivity of the melt and consequently improved the operation of the furnace tremendously (very smooth and quiet).

TEST 3

The test charge was a mixture of 8165 g of trap rock with 907 g of calcined limestone. Wool was sampled at 1530, 1440 and 1340°C. Wool was of a green colour. Visual examination and "hand-testing" suggested that samples collected at 1530 and 1440°C were of good quality whereas the wool formed at 1340°C was too coarse. About 260 g of metal was produced, which is in between the amounts obtained in Test 1 and 2. The 10% addition of calcined limestone in this test reduced the activities of the iron oxides compared with Test 2 but increased the activities compared with Test 1. Because of the lesser addition of calcined limestone, the furnace operation was not as smooth running as in Test 2 but nonetheless was very satisfactory.

TEST 4

The melt charge, although the same as for Test 3, i.e., 8165 g of trap rock plus 907 g calcined limestone, tended to fiberize at different temperatures. To obtain a precise control of the melt temperature, four temperature measurements of the melt were taken with the immersion-thermocouple-lance, and the holding time of the melt before tapping was 10-15 min longer than before. During this holding period, more electrical power was put into

the melt. These all contributed to a greater reduction of the iron oxide. In this test, 437 g of metal was produced, compared with 264 g in Test 3. Wool samples collected at 1600, 1500 and 1475°C are all of a white colour. The 1600°C wool was very fine and short, but wool from the other two temperatures was of reasonably good quality.

CONCLUSION

In these tests, the addition of calcined limestone to the trap rock increased the electrical conductivity of the melt and greatly improved the melting operation. The inherent reducing condition in the CANMET's electrical furnace resulted in the reduction of iron oxides from the melt. This reduction changed the viscosity of the melt and made the control of the fiberization process more complex. Perhaps a gas-fired furnace or an electric furnace with oxide refractory lining and non-submerged electrodes could alleviate this problem.